

Cesium

What Is It? Cesium is a soft, silvery white-gray metal that occurs in nature as cesium-133. The natural source yielding the greatest quantity of cesium is the rare mineral pollucite. American ores of pollucite, found in Maine and South Dakota, contain about 13% cesium oxide. Although it is a metal, cesium melts at the relatively low temperature of 28° C (82° F), so like mercury it is liquid at moderate temperatures. This most alkaline of metals reacts explosively when it comes in contact with cold water.

Symbol:	Cs
Atomic Number: (protons in nucleus)	55
Atomic Weight: (naturally occurring)	133

There are 11 major radioactive isotopes of cesium. (Isotopes are different forms of an element that have the same number of protons in the nucleus but a different number of neutrons.) Only three have half-lives long enough to warrant concern: cesium-134, cesium-135 and cesium-137. Each of these decays by emitting a beta particle, and their half-lives range from about 2 to 2 million years. The half-lives of the other cesium isotopes are less than two weeks. Of these three, the isotope of most concern for Department of Energy (DOE) environmental management sites such as Hanford is cesium-137 which has a half-life of 30 years. Its decay product, barium-137m (the "m" means metastable) stabilizes itself by emitting an energetic gamma ray with a half-life of about 2.6 minutes. It is this decay product that makes cesium an external hazard (that is, a hazard without being taken into the body). Cesium-135 and cesium-134 are typically of less concern because of their radiological decay characteristics. The very long half-life of cesium-135 means it has a very low specific activity, and the slow decay rate combined with its low decay energy contribute to its low hazard. Cesium-134 has a half-life of 2.1 years and decays by emitting a beta particle. The relatively small amount of cesium-134 produced more than 20 years ago would essentially all be gone today due to radioactive decay.

Radioactive Properties of Key Cesium Isotopes and an Associated Radionuclide

Isotope	Half-Life	Specific Activity (Ci/g)	Decay Mode	Radiation Energy (MeV)		
				Alpha (α)	Beta (β)	Gamma (γ)
Cs-134	2.1 yr	1,300	β	-	0.16	1.6
Cs-135	2.3 million yr	0.0012	β	-	0.067	-
Cs-137	30 yr	88	β	-	0.19	-
<i>Ba-137m</i> (95%)	2.6 min	540 million	<i>IT</i>	-	0.065	0.60

IT = isomeric transition, Ci = curie, g = gram, and MeV = million electron volts; a dash indicates that the entry is not applicable. (See the companion fact sheet on Radioactive Properties, Internal Distribution, and Risk Coefficients for an explanation of terms and interpretation of radiation energies.) Certain properties of barium-137m are included here because this radionuclide accompanies the cesium decays. Values are given to two significant figures.

Where Does It Come From? Cesium is naturally present as the isotope 133 in various ores and to a lesser extent in soil. The three radioactive cesium isotopes identified above are produced by nuclear fission. When an atom of uranium-235 (or other fissile nuclide) fissions, it generally splits asymmetrically into two large fragments – fission products with mass numbers in the range of about 90 and 140 – and two or three neutrons. (The mass number is the sum of the number of protons and neutrons in the nucleus of the atom.) Cesium radionuclides are such fission products, with cesium-135 and cesium-137 being produced with relatively high yields of about 7% and 6%, respectively. That is, about 7 atoms of cesium-135 and 6 atoms of cesium-137 are produced per 100 fissions. Cesium-137 is a major radionuclide in spent nuclear fuel, high-level radioactive wastes resulting from the processing of spent nuclear fuel, and radioactive wastes associated with the operation of nuclear reactors and fuel reprocessing plants.

How Is It Used? Cesium metal is used in photoelectric cells and various optical instruments, and cesium compounds are used in the production of glass and ceramics. Cesium-137 is also used in brachytherapy to treat various types of cancer. (Brachytherapy is a method of radiation treatment in which sealed sources are used to deliver a radiation dose at a distance of up to a few centimeters by surface, intracavitary, or interstitial application.)

What's in the Environment? Cesium-133 exists naturally as a stable isotope. The concentration of cesium in the earth's crust is 1.9 milligrams per kilogram (mg/kg), and the concentration in sea water is about 0.5 micrograms/kg. Cesium has been shown to biomagnify in aquatic food chains. Radioactive cesium is present in soil around the world largely as a result of fallout from past atmospheric nuclear weapons tests. The concentration of cesium-137 in surface soil from fallout ranges from about 0.1 to 1 picocurie (pCi)/g, averaging less than 0.4 pCi/g (or 0.3 billionth of a milligram per kilogram soil). Cesium is present as a contaminant at certain facilities, such as nuclear reactors and facilities that process spent nuclear fuel.



Cesium is generally one of the less mobile radioactive metals in the environment. It preferentially adheres quite well to soil, and the concentration associated with sandy soil particles is estimated to be 280 times higher than in interstitial water (water in the pore space between soil particles); concentration ratios are much higher (about 2,000 to more than 4,000) in clay and loam soils. Thus, cesium is generally not a major contaminant in groundwater at DOE sites. At Hanford, the highest concentrations of cesium-137 are in areas that contain waste from processing irradiated fuel, such as in the tanks in the central portion of the site and to a lesser degree in the former liquid disposal areas along the Columbia River.

What Happens to It in the Body? Cesium can be taken into the body by eating food, drinking water, or breathing air. After being taken in, cesium behaves in a manner similar to potassium and distributes uniformly throughout the body. Gastrointestinal absorption from food or water is the principal source of internally deposited cesium in the general population. Essentially all cesium that is ingested is absorbed into the bloodstream through the intestines. Cesium tends to concentrate in muscles because of their relatively large mass. Like potassium, cesium is excreted from the body fairly quickly. Ten percent is excreted with a biological half-life of 2 days, and the rest leaves the body with a biological half-life of about 110 days. This means that if someone is exposed to radioactive cesium and the source of exposure is removed, much of the cesium will readily clear the body along the normal pathways for potassium excretion within several months.

What Are the Primary Health Effects? Cesium-137 presents an external as well as internal health hazard. The strong external gamma radiation associated with its short-lived decay product barium-137m makes external exposure a concern, and shielding is often needed to handle materials containing large concentrations of cesium. While in the body, cesium poses a health hazard from both beta and gamma radiation, and the main health concern is associated with the increased likelihood for inducing cancer.

What Is the Risk? Lifetime cancer mortality risk coefficients have been calculated for nearly all radionuclides, including cesium (*see box at right*). While the coefficients for ingestion are somewhat lower than for inhalation, ingestion is generally the most common means of entry into the body. Similar to other radionuclides, the risk coefficients for tap water are about 80% of those for dietary ingestion.

In addition to risks from internal exposures, there is a risk from external gamma exposure. Using the external gamma risk coefficient to estimate a lifetime cancer mortality risk, if it is assumed that 100,000 people were continuously exposed to a thick layer of soil with an initial average concentration of 1 pCi/g cesium-137, then 6 of these 100,000 people would be predicted to incur a fatal cancer. (This is in comparison to the 25,000 people from the group predicted to die of cancer from all other causes per the U.S. average.) This risk is largely associated with the gamma ray from barium-137m.

Radiological Risk Coefficients

This table provides selected risk coefficients for inhalation and ingestion. Recommended default absorption types were used for inhalation, and dietary values were used for ingestion. The cesium-137 values include the contribution from the decay product barium-137m. (See text at left for information on the external gamma exposure pathway) Risks are for lifetime cancer mortality per unit intake (pCi), averaged over all ages and both genders (10^{-12} is a trillionth). Other values, including for morbidity, are also available.

Isotope	Lifetime Cancer Mortality Risk	
	Inhalation (pCi^{-1})	Ingestion (pCi^{-1})
Cesium-134	1.1×10^{-11}	3.5×10^{-11}
Cesium-135	1.3×10^{-12}	4.0×10^{-12}
Cesium-137	8.1×10^{-12}	2.5×10^{-11}

For more information, see the companion fact sheet on Radioactive Properties, Internal Distribution, and Risk Coefficients and the accompanying Table 1.